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## Scientific Note

# *HESPEROPSIS GRACILIAE* (MacNEILL) (LEPIDOPTERA: HESPERIIDAE) FLIGHT BETWEEN HOSTPLANTS AND *PROSOPIS GLANDULOSA* TORREY

MacNeill's sootywing skipper, *Hesperopsis graciliae* (MacNeill), is a small (wingspread ≈ 23 mm) dark-gray butterfly found along the lower Colorado River and near the river along its tributaries in southeastern California, western Arizona, southern Nevada, and southern Utah (Scott, J. A. 1986. The butterflies of North America: a natural history and field guide. Stanford Univ. Press, Stanford, Calif.). Flights of *H. graciliae* occur from April to October in two (Emmel, T. C. & J. F. Emmel. 1973. The butterflies of southern California. Nat. His. Mus. Los Angeles Co., Sci. Series, 26: 1–148.) or three (Austin, G. T. & A. T. Austin. 1980. J. Res. Lepidoptera, 19: 1–63.) generations. Larvae of *H. graciliae* feed only on *Atriplex lentiformis* (Torrey) (Chenopodiaceae), a shrub found in dense clumps along lower Colorado River drainages (Emmel & Emmel 1973) that is halophytic and typically dioecious (Turner, R. M., J. E. Bowers & T. L. Burgess. 1995. Sonoran desert plants: an ecological atlas. Univ. Ariz. Press, Tucson.). *Hesperopsis graciliae*, however, is only sporadically encountered compared with the distribution of its larval host (Austin & Austin 1980). The apparent rarity of this butterfly, and concern over habitat destruction due to urban and agricultural development, has afforded *H. graciliae* the global rank of 'G3?' (L. Jaress, Ariz. Game & Fish Dept., Phoenix, personal communication), indicating that the conservation status of the species is uncertain but currently considered as rare or uncommon but not imperiled (Master, L. L. 1991. Conservation Biol., 5: 559–563.).

The rarity of *H. graciliae* compared with that of *A. lentiformis* suggests that factors other than larval-host availability influence its occurrence. One such factor may be the availability of a food source for *H. graciliae* adults. *Hesperopsis graciliae* adults must forage on other plant species, because *A. lentiformis* is wind-pollinated (Turner et al. 1995) and does not produce nectar, and foraging flights between plant species would be expected. However, *H. graciliae* adults are reported as seldom straying from the cover of their hostplants (Howe, W. H. [ed.]. 1975. The butterflies of North America. Doubleday & Co., Garden City, New York.). The present study describes and analyzes flights by *H. graciliae* between *A. lentiformis* and honey mesquite, *Prosopis glandulosa* Torrey (Fabaceae), a riparian plant of the lower Colorado River not used by *H. graciliae* larvae.

The study site was located on the upper floodplain along the southern edge of the Bill Williams River 3 km east of Lake Havasu, a Colorado River reservoir, at the northern boundary of La Paz County, Arizona. The site lies within the Sonoran Desert biome (Turner, R. M. & D. E. Brown. 1982. Sonoran desertscrub. pp. 181–221. *In* Brown, D. E. [ed.]. Biotic communities of the American Southwest—United States and Mexico. Desert Plants 4 [1–4].) at an elevation of 150 m. Precipitation (measured 19 km south near Parker, Ariz.) during the previous 12 mos (20 mm) had been 21% of the annual average (97 mm, Turner & Brown 1982). Principal vegetation at the site is *A. lentiformis*, *Acacia greggii* Gray, *Pluchea sericea* (Nutt.), *Cercidium* sp., *P. glandulosa*, and *Salix gooddingii* Ball. *Hesperopsis graciliae* flights were observed between a 14 m × 5.5 m × 3 m high closed-canopy patch of *A. lentiformis* male and female plants and a 16 m × 13 m × 6 m high closed-canopy patch of clumped *P. glandulosa.* The edges of the *A. lentiformis* and *P. glandulosa* canopies were 4.0 m apart and separated by a dirt and gravel road that traversed the site from east to west. The north edge of the road transected 4.6 m of the *A. lentiformis* canopy, and the south edge of the road transected 9.8 m of the *P. glandulosa* canopy. The *P. glandulosa* was not in flower.

*Hesperopsis graciliae* flights between the plant canopies were observed, beginning at approximately 0930 MST, for 4 hrs on 17 and 20 Sep and for 2.5 hrs on 24 Sep 1996. A line of 5-cm diam. rocks 2 m apart was placed along the center of the road, and the time was recorded when a *H. graciliae* was observed flying across the line of rocks en route to either the *A. lentiformis* or *P. glandulosa.* Air temperature at the site was recorded hourly and averaged 30.8, 30.6, and 34.4° C on the three dates, respectively. Two *H. graciliae* adults (1 male and 1 female) were collected from the *A. lentiformis* on 26 September, verified as to species (G. Austin, Nev. St. Mus., Las Vegas, personal communication), and deposited as voucher specimens at the University of Arizona Insect Museum, Tucson.

The number of *H. graciliae* flights to *A. lentiformis* and to *P. glandulosa* on each date was compared against an expected proportion of 1:1 using a $\chi^2$ test. The sequence of flight directions observed on each date was analyzed with a runs test (Sokal, R. R. & F. J. Rohlf. 1981. Biometry [2nd ed]. W. H. Freeman & Co., New York.), a nonparametric method that uses the $t_s$-distribution to test if an observed sequence of dichotomized events, in this case flight to *A. lentiformis* or to *P. glandulosa*, departs from random. Significant ($P < 0.05$), positive values of $t_s$ ($>1.960$) indicate flight directions that alternate in sequence, whereas negative values of $t_s$ ($<-1.960$) indicate sequences with each flight direction tending to repeat. In addition to performing runs tests on observed sequences of flight direction, runs tests were performed on sequences of flight direction after shifting the observed times of flight to *A. lentiformis* earlier by 1, 2, 3, 4, and 5 min. Shifting the time of flight allowed determining if flights to *A. lentiformis* were delayed behind those to *P. glandulosa* by a constant interval on each date.

A total of 267 flights by *H. graciliae* was observed between the *P. glandulosa* and *A. lentiformis* canopies during the 10.5 hrs that the site was monitored (Table 1). *Hesperopsis graciliae* flew close to the ground, rarely exceeding a height of 20 cm, when traversing the open area between the plants and exhibited the fluttering, bouncy pattern as has been previously described (MacNeill, C. D. 1970. Entomol. News, 81: 177–184, Ferris, C. D. & F. M. Brown [eds.]. 1981. Butterflies of the Rocky Mountain states. Univ. of Okla. Press, Norman.). Flights to *P. glandulosa* were slower and with more wandering than those to *A. lentiformis*, and therefore more easily observed. Although *H. graciliae* flying to *A. lentiformis* frequently landed near the periphery of the plant canopy, few adults flying to *P. glandulosa* similarly landed; most adults instead continued their flight into the interior of *P. glandulosa*'s comparatively less-dense canopy.

The number of flights to *A. lentiformis* compared with those to *P. glandulosa* did not differ significantly ($P > 0.05$) within each date (Table 1). Across all three dates, the median time interval between successive flights to *P. glandulosa* was

Table 1. Frequency and interval of *Hesperopsis graciliae* flights between *Prosopis glandulosa* and *Atriplex lentiformis*.

| Date | Plant species flown to | No. of flights | $\chi^2$ | Interval between successive flights (min) Median | Range |
|---|---|---|---|---|---|
| 17 Sept. | *P. glandulosa* | 74 | 1.69[a] | 2.42 | 0.08–11.42 |
| | *A. lentiformis* | 59 | | 3.21 | 0.08–15.92 |
| 20 Sept. | *P. glandulosa* | 51 | 3.40[a] | 2.92 | 0.08–18.17 |
| | *A. lentiformis* | 34 | | 4.50 | 0.08–21.50 |
| 24 Sept. | *P. glandulosa* | 29 | 1.65[a] | 3.75 | 0.08–21.92 |
| | *A. lentiformis* | 20 | | 4.17 | 0.17–28.00 |

[a] No. of flights compared; n.s. (1 df, $P > 0.05$).

2.83 min, and the median time interval between successive flights to *A. lentiformis* was 3.58 min. The median time interval between successive flights to either plant species was 1.33 min across all three dates.

The observed sequence of *H. graciliae* flight direction, to *A. lentiformis* or to *P. glandulosa*, did not depart from random on any of the dates sampled (Table 2). Alternating sequences in flight direction were detected after the observed times of flight to *A. lentiformis* were shifted earlier by 2 min on 17 September, by 4 min on 20 September, and by 1 min and 2 min on 24 September. Observed flights to *A. lentiformis* therefore were delayed behind observed flights to *P. glandulosa* by a constant interval on each date. The interval corresponding to the delay, however, varied between dates. Flights to *A. lentiformis* occurred approximately 3 min later than flights to *P. glandulosa* after averaging the delays (2, 4, and 1.5 min) across dates. A maximum of 6, 5, and 4 flights consecutively in the same direction was observed on the three dates, respectively.

In contrast to previous descriptions of *H. graciliae* as a weak flyer preferring to remain within foliage (MacNeill 1970, Howe 1975), the present study found the species frequently (approx. once every 1.3 min) flying across a 4 m span of open terrain that separated larval-host and non-host plants. The frequent flights by *H. graciliae* between plant canopies, lack of significant difference between the number of flights to *A. lentiformis* compared with those to *P. glandulosa*, and sequences of alternating flight direction detected between the plant canopies, indicate that individual *H. graciliae* adults were repetitively flying back and forth between the two plant species. The maximum number of flights consecutively in

Table 2. Values of $t_s$ testing if sequences of *Hesperopsis graciliae* flight direction, to *Prosopis glandulosa* or to *Atriplex lentiformis*, deviate from random.[a]

| Date | Observed flight direction sequence | Flight direction sequence after shifting times of flight to *A. lentiformis* earlier: Shift of 1 min | Shift of 2 min | Shift of 3 min | Shift of 4 min | Shift of 5 min |
|---|---|---|---|---|---|---|
| 17 Sept. | 1.648 | 1.295 | 2.177[b] | 0.414 | 1.472 | 0.061 |
| 20 Sept. | 1.638 | 1.865 | 0.273 | 1.410 | 2.320[b] | 0.955 |
| 24 Sept. | 0.996 | 2.790[c] | 2.192[b] | 0.996 | −0.798 | 0.398 |

[a] Runs test for dichotomized data (Sokal & Rohlf 1981).
[b] Alternating sequence in flight direction (df = ∞, $P < 0.05$).
[c] Alternating sequence in flight direction (df = ∞, $P < 0.02$).

the same direction (4-6 across dates) therefore provides an estimate of the insect's minimum population density on the *A. lentiformis*, and the average 3-min delay between flights to and from the *P. glandulosa* represents the time spent by *H. graciliae* at that plant species.

The benefit gained by *H. graciliae* repetitively flying from hostplants to *P. glandulosa* is not clear. For example, the insects may have been flying into *P. glandulosa*'s shaded interior for thermoregulation, the flights may have been associated with mate finding and reproduction, or the insects may have been searching for additional hostplants. I suggest that the observed flights represent foraging behavior by *H. graciliae*, an hypothesis supported by the presence of extrafloral nectaries on *P. glandulosa* (Pemberton, R. W. 1988. Madroño, 35: 238–246.). I found one nectary located between each of the paired, primary leaflets and several nectaries along the rachis between the secondary leaflets (see Hickman, J. C. [ed.]. 1993. The Jepson manual: higher plants of California. Univ. of Calif. Press, Berkeley.). Leaf-rachis nectaries from the *P. glandulosa* examined under magnification were exuding nectar, and *H. graciliae* were observed landing on the secondary leaflets. However, these observations were infrequent due to the difficulty of tracking the insects once they entered the *P. glandulosa* canopy, and the insect's small size and tendency to land on interior foliage prevented observing if their proboscises were extended and in contact with leaf-rachis nectar.

The hypothesis that *H. graciliae* were foraging at *P. glandulosa* extrafloral nectar is supported by the insect's opportunistic feeding as an adult. They have been reported to feed at flowers of an exotic weed, *Tamarix pentandra* Pallas (= *T. ramosissima*) (Tamaricaceae), a crop (alfalfa), *Medicago sativa* L. (Fabaceae), and a native plant, *Heliotropium curassavicum* L. (Boraginaceae) (Austin & Austin 1980). During the present study, I observed *H. graciliae* feeding at flowers of *Bebbia juncea* (Benth.) (Asteraceae) ≈ 0.25 km from the study site and the only insect-pollinated plants in flower in the vicinity. Adult Lepidoptera will feed on extrafloral nectar, and extrafloral nectar has been suggested to provide nectar-feeding insects an alternative food source when other sources are rare (Rogers, C. E. 1985. Bull. Entomol. Soc. Amer., 31: 15–20.). Alternative food sources may be important to *H. graciliae*, because floral nectar would be less abundant during the insect's fall flight. Additional effort is needed to determine if *H. graciliae* were foraging when repetitively flying to *P. glandulosa* or if the observed flights were due to other physiological demands, the significance of *P. glandulosa* extrafloral nectar as a food source to *H. graciliae* adults, and the influence of *P. glandulosa* on the insect's distribution and abundance.

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W. D. Wiesenborn, *U.S. Bureau of Reclamation, P.O. Box 61470, Boulder City, Nevada 89006-1470.*

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